Transmission characteristics of 1.3µm Fabry-Pérot laser diodes integrated with spot-size converter for 2.5Gbit/s applications.

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Abstract : This article demonstrates the application of highly efficient Fabry-Pérot lasers to intra-office STM-16 fiber communication systems at the wavelength of 1.3µm. Low power penalty of 0.05dB through a 12 ps/nm fiber was measured at 25°C and 85°C . A record coupling loss as low as 1dB of a laser to a cleaved SMF (ϕ= 9.5 µm) fiber is achieved. This device consists of an active stripe followed by a passive intracavity spot-size converter (SSC). Subsequently, this paper demonstrates the feasibility of non-perturbing intracavity tapers through the application of selective area growth.

Objective : The quest for low cost and better in-fiber quantum efficiency leads us to the problem of maximizing the ratio of in-fiber power to total laser emitted power. As an approach to this, we have proposed a highly adiabatic spot-size converter where the mode expansion is done by the monolithic integration of a passive guide varying slowly in the vertical direction. Besides the careful design of a low reflection butt-joint, the vertical taper profile is tailored by selective area growth. This ensures a minimum perturbation of the phase of each longitudinal mode. These features are fundamental to obtain a well-behaved spectrum. Our approach combines 2.5 Gbit/s transmission capabilities, excellent coupling and good spectral properties.

Device description: Fig. 1 shows the geometry and layout of the laser with integrated SSC. The active part consisted of a system of 9 InAsP strained-well MQW making a buried ridge structure. The stripes are 1.3µm wide and 300µm long. The fabrication of this device consisted of only three epitaxial growth steps applied to an InP-n substrate. The first epitaxial step grows by GSMBE the active structure onto the substrate. After this, the place for the spot size converter is etched with a 15° lateral tilt by reactive ion etching (RIE) through a carefully designed mask. Then a second epitaxy by selective area MOVPE growth (SAG) is performed. This process adds the passive part of the device; it also defines a vertical profile that is highly dependent on the mask pattern previously applied. The mesa shape of the active and passive waveguides is defined by standard lithography and etched by RIE. The last epitaxial step is the growth of the p-doped cladding layers onto the whole wafer. The passive part is then hydrogenated using an H_2 plasma in order to inhibit the charge carriers of the InP-p layer, and to reduce the absorption losses. This improves both the threshold current and the quantum efficiency of the laser [1]. A highly reflecting coating is applied to the laser facet on the active side and no coating was applied to the taper side of the laser.

Results and Discussion. A set of measurements was performed on the devices. The CW characteristics of the lasers are shown in fig. 2. Threshold currents as low as 4 mA and 14 mA were obtained respectively at 25° and 85°C. The external efficiencies were 0.43W/A and 0.25 W/A at 25°C and 85°C respectively. It was observed that the far fields patterns were symmetrical and without side lobes, with beam divergence angles at FWHM around 8° in both directions. The lasing spectra of all the measured lasers were unperturbed and noiseless. Fiber coupling losses of 1 dB were obtained and alignment tolerances of ±2 µm within 1 dB from the maximum coupling intensity were observed (fig3). The suitability of these lasers as an optical source for telecommunications are apparent from tests that were performed in an STM 16 intra-office system with 12ps/nm fiber. Power penalties as low as 0.05 dB at a sensitivity of 10^{-10}, at operating temperatures of 25°C and 85°C were observed (fig4).

Conclusion. The application of highly efficient Fabry-Pérot lasers with intra-cavity spot size converter was demonstrated for intra-office STM16 systems. Optimal spectral and high temperature performances as well as extremely low coupling losses of 1dB were observed. The inclusion of all these features in a single monolithic device, renders this type of laser suitable as a light source for low-cost subscriber fiber communications.

[1]D.Trégoat et al.”High-efficiency 1.3 µm FP laser diode based on hydrogenated passive spot-size converter” in Proc.IPRM’2000, paper TuB 26

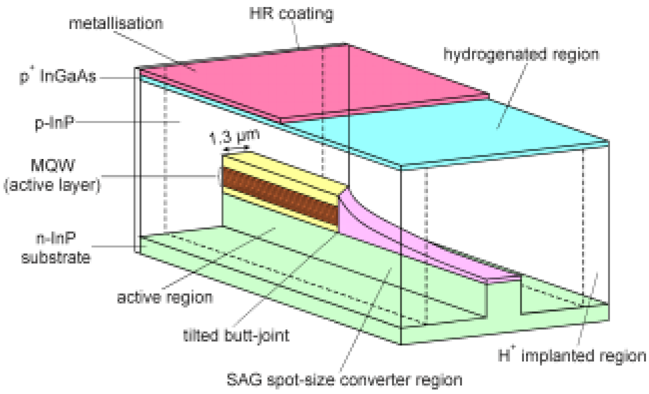

Fig.1Schematic structure of the LD integrated with a spot-size converter

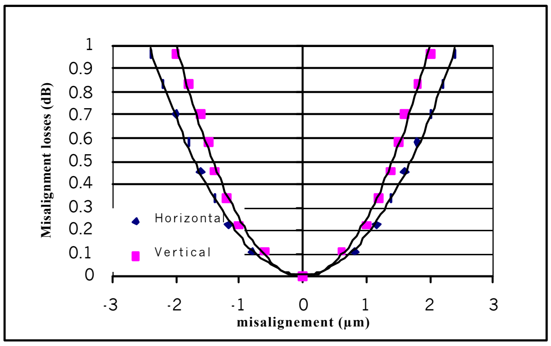

Fig.3: Alignment tolerances for coupling into flat-end SMF.

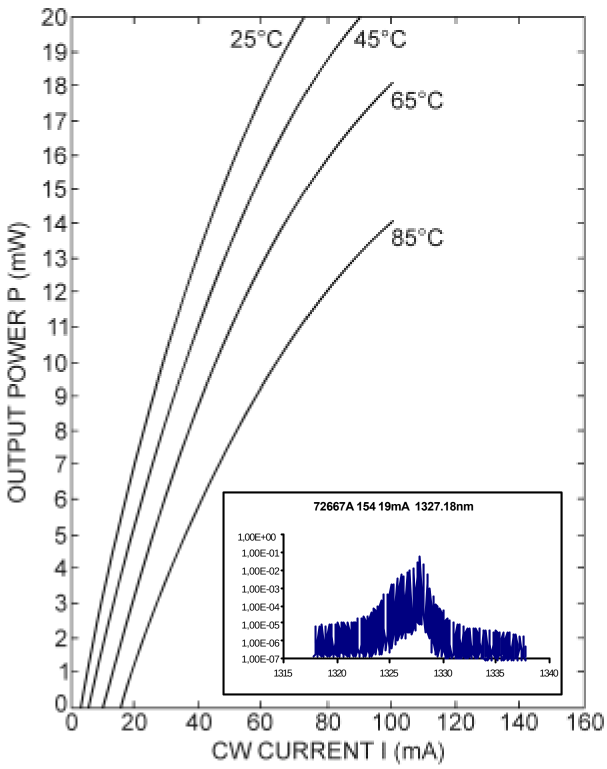

Fig.2: L-I characteristics at different temperatures and lasing spectrum at 5 mW and 25°C

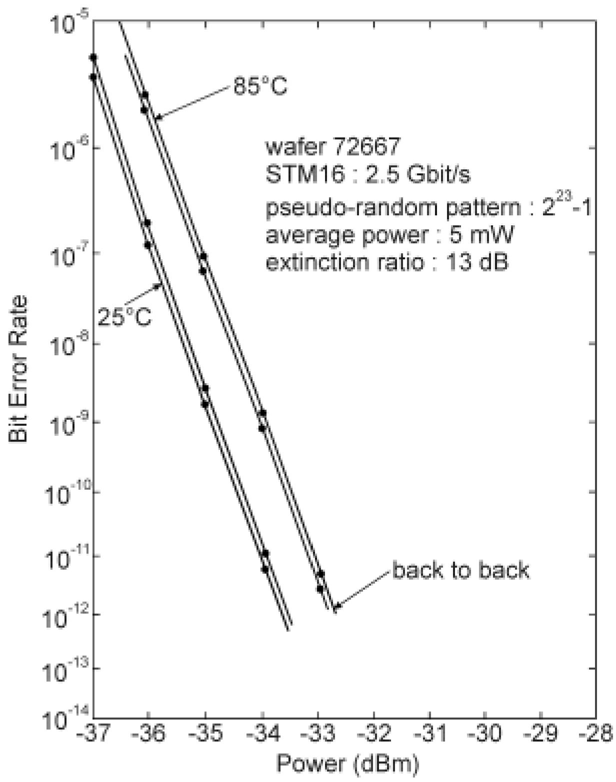

Fig.4: BER performance at 2.5 Gbit/s for 25° C and 85°C.